Simulation of Hirakud Reservoir to Study Conservation of Water

A thesis submitted in partial requirement for

Degree in Bachelor in Technology in

Civil Engineering

By

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CERTIFICATE

This is to certify that the thesis entitled, “Simulation of Hirakudreservoir to study conservation of water”, submitted by **SoumyaRanjan Dhal**in partialfulfillment of the requirements for the award ofBachelor of Technology Degree inCivil Engineering at the National Institute of Technology, Rourkela is an authenticwork carried out by him under my supervision and guidance.To the best of my knowledge, the matter embodied in the thesis has not beensubmitted to any other University/Institute for the award of any Degree orDiploma.

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Last but not the least I would thank my friends, parents and the All Mighty without whose blessings and care the task of completion would have been tougher.

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Content:

ABSTRACT

With climate changing so rapidly and weather being completely unpredictable nowadays, it has been a cause of concern to predict rainfall. In a country like India the rainfall being completely seasonal and the amount of rainfall being so less, it has been a tough task for engineers to find out innovative ways to keep water in abundance till the rain arrives. If the engineers were taking initiatives for preserving water for future use, a heavy constant rainfall for days may cause flood in the nearby areas. So an assessment became necessary to carry out observations using the previously recorded data of flow of water in a river so that they can predict amount of water to be present in a reservoir monthly so that water can be supplied for all demands including high priority demand, low priority demand and maintain a downstream flow. So experimental models were made and observed which lead to results of different levels of water in different months so that water supply made is enough to meet the requirements. Further, these models were used to predict water requirements for Irrigation and Hydropower so that failure of crops and power scarcity can be eradicated to some extent. Thus these small models or simulation operation on reservoirs have completely revolutionized the world with its effective results by successfully helping in predicting the water requirement and availability so that further initiatives can be taken to have a supply of water in downstream as well as for high priority demands throughout the year. In this thesis a similar study is done by me by collecting all data for 5 years and making an experimental model using the newly developed software, NIH-ReSyP, by National Institute of Hydrology, Roorkee to know the effective nature of experimental model of the reservoir.

Being Familiar:

What is simulation?

Simulation is a process in which a model demonstration of a natural cycle or any man made system is done over time to study characteristics of that natural cycle or manmade system.

Here there is a case study based upon “Operation of a Reservoir”.

Simulation operation of reservoir is done to predict the motion, amount, discharge of fluid using a computer model which helps us in flood prediction, water discharge amount (so that a minimum amount of water can be retained throughout the year so that we can supply water in case of drought period).

In this software “NIH_ReSyP” is used for the simulation operation of reservoir. Case study is done on Hirakud Reservoir. The main theme of the operation is conservation of water.

NIH_ReSyP: A Brief Description

NIH_ReSyP(System Resource Package) is a Windows based software which is developed in Visual BASIC platform. It is used to do several analysis and simulation related to hydrology. It’s main purpose is to perform analysis of reservoir system. It gives output in tabular form in notepad format.

Hirakud Reservoir: A Brief Introduction:

It is the largest lake of Asia covering an area of 746 sq km. It has a shore line of more than 640 km. The length of the dyke is 21 km. The reservoir length is 55 km.The capacity of reservoir is 5896 MCM.

A trial is made to observe various characteristics of the Hirakud Reservoir.

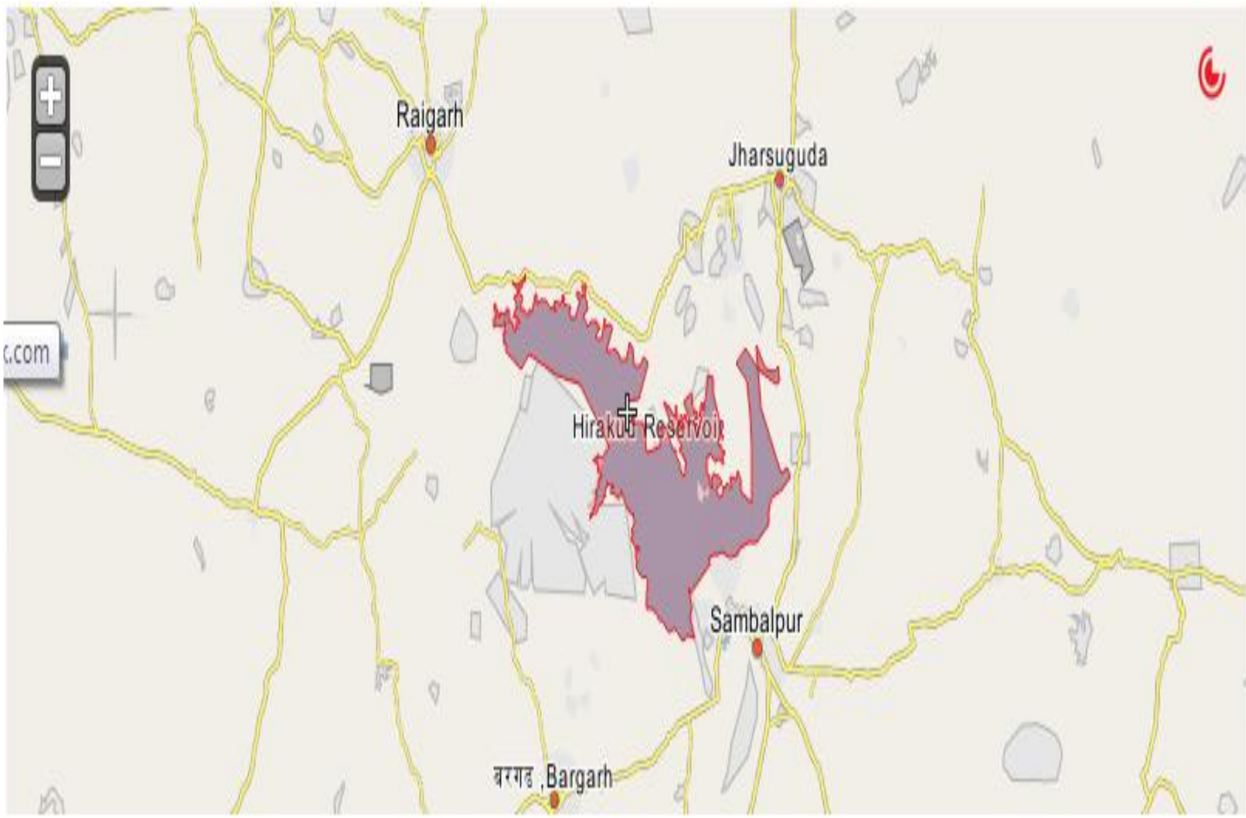


Figure showing Hirakud Reservoir.

Literature Assessment:

It is the first attempt of performing reservoir simulation using the software NIH_ReSyP.

Previously reservoir simulation was done. They are as follows:

- Reservoir Operation using Multiple Regressed Monthly operation Rules by:Panigrahi, Subodh and Dash, Sanat (2008) *Reservoir Operation using Multiple Regressed Monthly operation Rules.*BTech.

- Studies are also carried out by Orissa Hydropower Corporation Limited for power demands.http://www.ohpcltd.com/index.asp?type=sindhol

- Hydraulic structure for flow diversion and storage. Version 2 Department of Civil Engineering (IIT Kharaghpur) http://nptel.iitm.ac.in/courses/Webcoursecontents/IIT%20Kharagpur/Water%20Resource%20Engg/pdf/m4l05.pdf

Applications of the Model:

- It is used to compute number of :
  - Failure months in Irrigation.
  - Failure months in hydropower.
  - Failure in water supply.
- It also computes the total number of months in which there was a failure in maintaining specified percentage of water release for meeting the demands. Those months are referred as "Critical Failure Months".
- The model gives a table as output which provides us with following information:
  - Year
  - Month
  - Operation Period
  - Storage at the start of this operation or initial storage.
  - Received flow from the upstream structure if present.
  - Intermediate catchment flow.
  - Evaporation
  - Irrigation demand
  - Water supply demand
  - Hydropower demand
  - Downstream demands
  - Release made for the above demands
  - Failure level (if present)
  - Power generated actually
  - Spill made by the structure
  - and end level

All these information help an hydrology engineer in deciding the best policy of for reservoir functioning thus causing an optimized performance.

DataAvailiabilty:

Some data were provided and some data were collected.

- Data provided:
  - 5 yrs runoff data starting from 1998 to 2003.
  - Monthly power demand.
  - Monthly irrigation demand.
  - Evaporation depths.
  - Elevation Area Capacity table.
- Data collected:
  - Gross capacity at FRL (Flood rule level)and MDDL (Minimum Draw Down Level)
  - Reduction factors for irrigation and hydroelectricity.
  - Installed capacity of Power plants.
  - Tail water elevation
  - Minimum Reservoir level for generation of hydropower.

Study Area:

Hirakud reservoir is located 15 km from Sambalpur city. The co-ordinates of Hirakud reservoir are 21.57°N 83.87°E. Artificial lake covers an area of 743sq. kilometers. Total power generated is 307.5MW. FRL (Flood Rule level) of the reservoir is 192.024 meters. The capacity of reservoir is 5896000000 cubic meters. The area of catchment is 83400 sq. kilometers.Its dead storage level is 179.830 meters.

Terminology:

Flood Rule Level:

It is the level of reservoir above which, if water rises, is spilled. As a result of which the level comes back to FRL. It is the level upto which a reservoir can hold water.

Minimum Drawdown Level:

It is the level below which, if the reservoir level falls, results in absence of meeting of all demands and the month in which this occurs is called a failure month.

Reduction factor for irrigation in scarcity:

It is applied in case the reservoir level falls below critical level for irrigation supply. In this scenario irrigation supply is cut to some percent so that other high priority demands can be met.

Reduction factor for hydropower in scarcity:

A certain reservoir level is required to generate hydropower. If the level falls below this, then complete hydropower and other main demands fail for the year in whole. So a certain percentage is cut so that other high priority demands can be met which are also reduced to certain percentage.

Factor defining critical conditions:

It is generally less than hydropower and irrigation reduction factors. If amount of supply goes below the critical limit (i.e. demands * critical factor) then failure may take place. In order to avoid such situations a factor for critical condition is defined.

Tail water elevation:

This data is provided to calculate available water head for generation of hydropower.

Efficiency of power plants:

It is required to calculate the actual production of hydropower from the available water head. It is generally less than the actual or theoretical capability of power plants. Generally it ranges between 85% to 90%.

Rule curves:

Rule curves are charts or graphs which define the maximum or limiting values of monthly water storage which enables an engineer to control the operations of reservoir. There are 4 types of rule curves. They are:

- Upper rule level
- Upper middle rule level
- Lower middle rule level
- Lower rule level

Upper Rule Level:

It is the maximum level up to which a reservoir can hold water. The upper rule level can either be flood rule level or less than flood rule level. A reservoir having water up to this level then the area to which it is supplying water can meet full demand throughout the year. If the reservoir has water more than this level then water is spilled through spillways to the downstream bed of river.

It is generally recommended to make spill so that encroachment of downstream river bed is prevented. Upper rule level should be kept below Flood rule level so that flood can be absorbed and prevented.

Upper Middle Rule Level:

This speaks of the scenario when water is less and supply for several demands cannot be made. So demands having low priority are restricted so that partial demands can be met for the whole year.

Curtailment is based on the priority between the two i.e. irrigation and hydropower based on the requirement in that area in that month.

Suppose irrigation is of greater demand in a certain area then rule curve condition of hydropower is considered and curtailment is done in hydropower or vice versa. For reservoir level greater than first middle rule level full supply for all demands is made. In case the reservoir level falls below the first middle rule level then curtailment based on priority, i.e. the demand with lowest priority is made so that other demands can be met. The release of water is made in a low amount in compared to the normal release so that a part of all demands can be met for a longer duration.

Lower Middle Rule Levels:

It is the scenario in which lack of fulfilling high priority demands is faced even if curtailment are made from demands having lowest priority is made. In this case complete restriction is made on demands having least priority so that complete supply for high priority demands and minimum demands of downstream are made.

Lower Rule Level:

It is the most vital part for supply of water and maintaining a minimum downstream flow. In case water level of reservoir falls below this level then, only water supply and minimum downstream flow is considered and release is made for demands such as irrigation, hydropower. If the release passes through the power plant then some incidental power generation may take place.

Evaporation Depth:

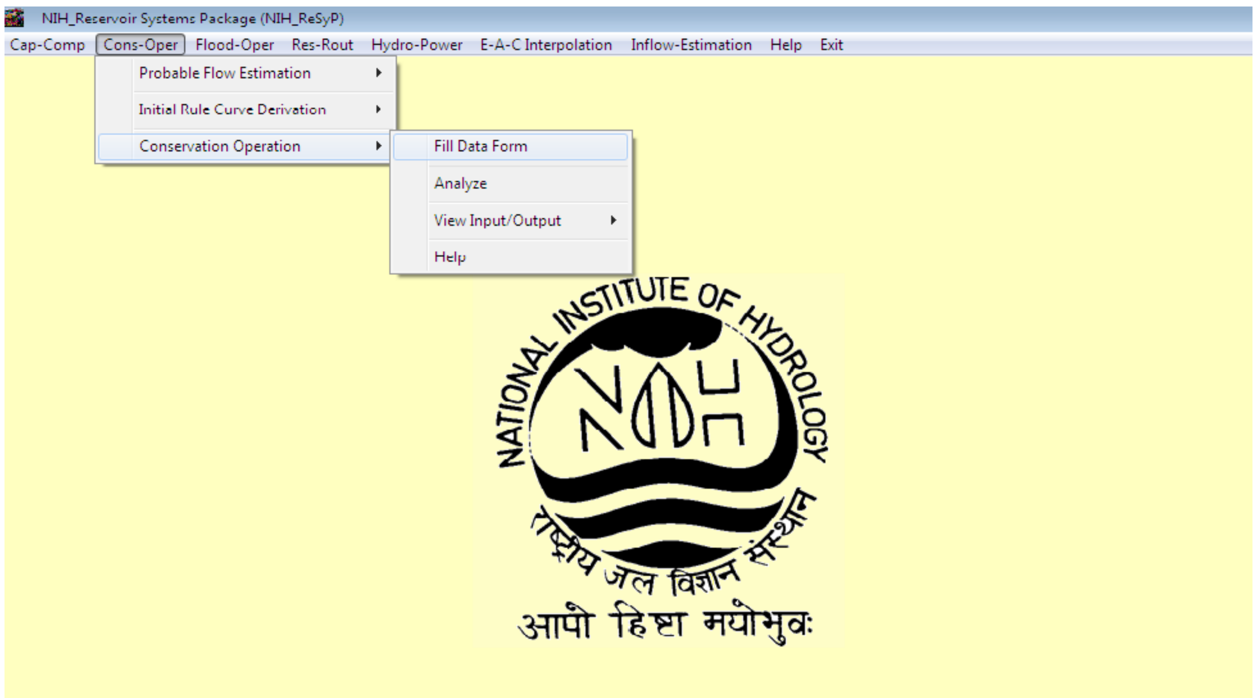
It is the measurement of loss of moisture in evaporation in an unit area in a certain time. It is measured in inches or mm or cm.

Conversion factors used:

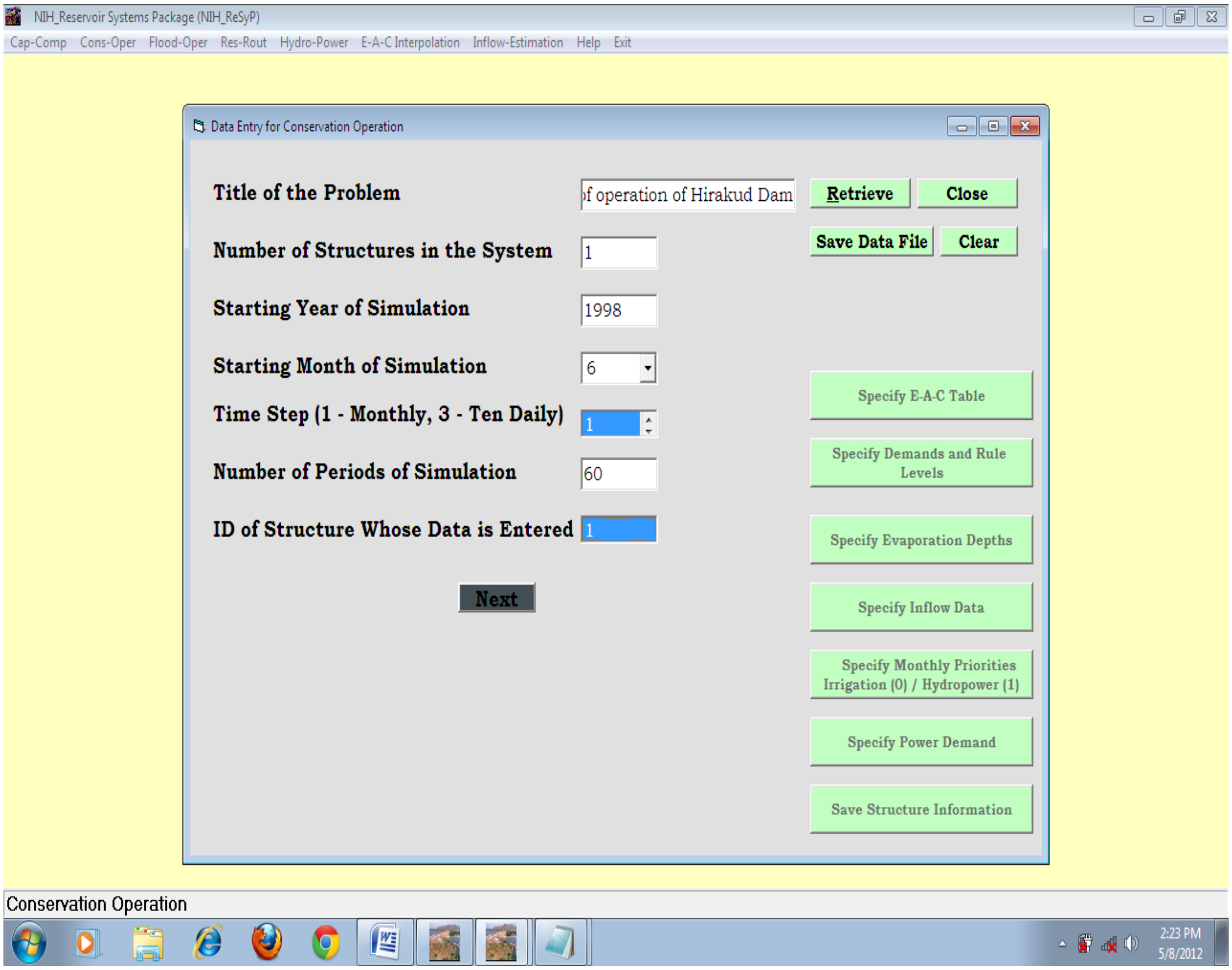
- MCM to CM – 1000000
- M to M – 1
- Sq KM to sq M – 1000000
- MKW to KW – 1000000

Methodology:

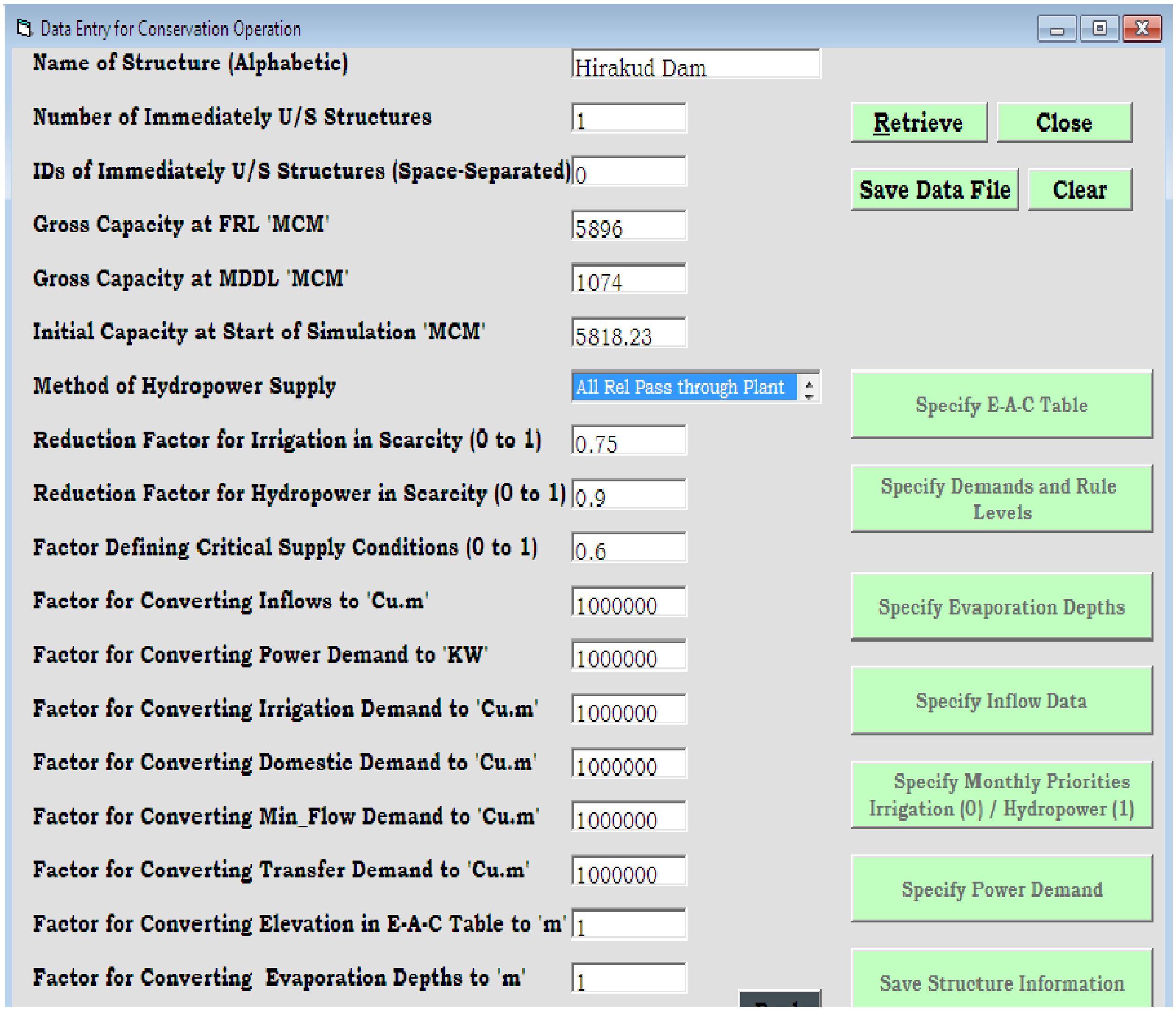
- ❖ Double click on NIH-ReSyPicon then click on start ReSyp. This will open a page with different modules available.
- ❖ Choose “Con-Opr” then click on “conservation operation” from the drop down which will lead to another drop down list.
- ❖ Choose “Fill data form” option. As shown below:



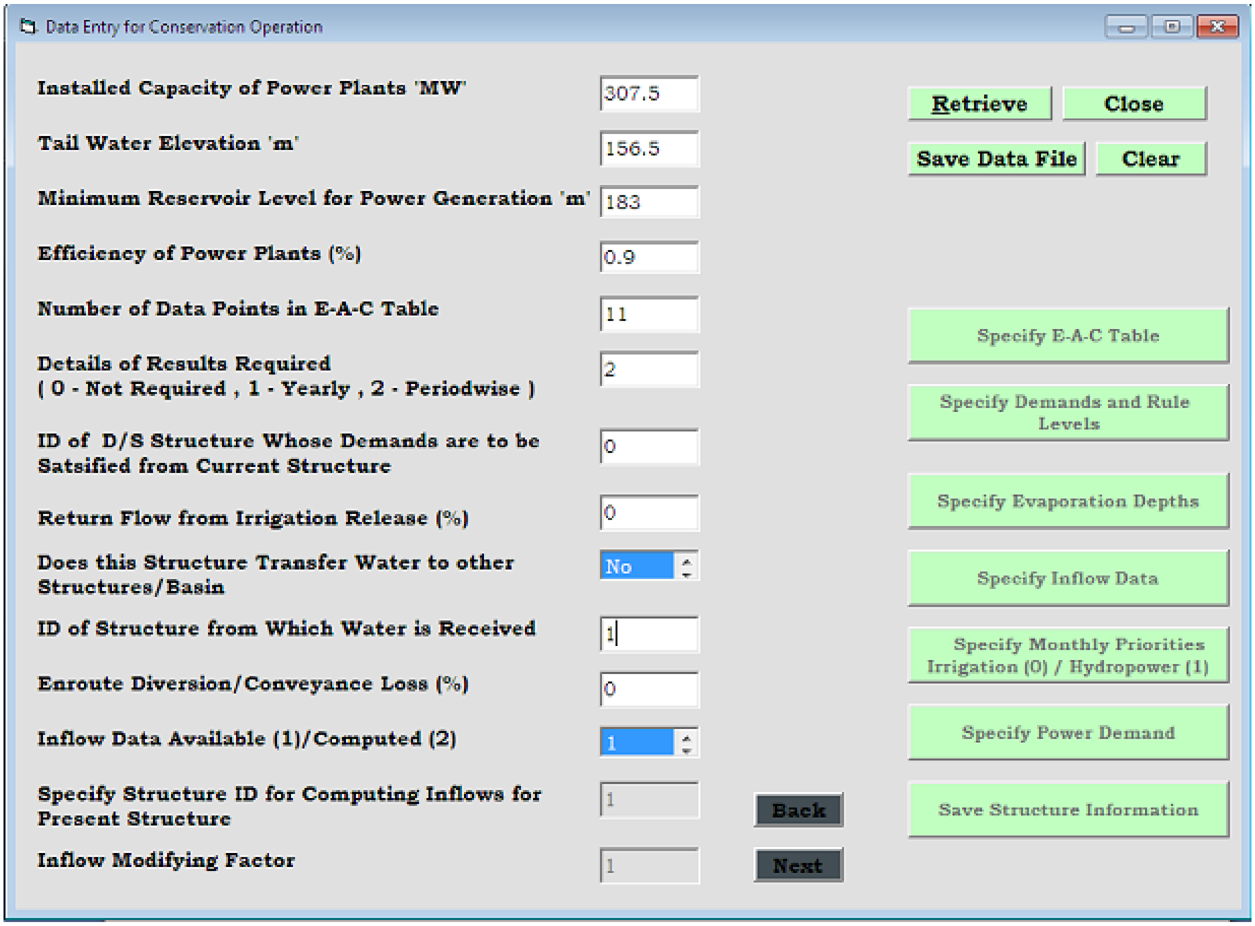
- ❖ Enter the asked data in the boxes given as shown in figures below:



- Click on the box available for "ID of Structure Whose Data is Entered" so that it gets highlighted.
- Then click on the "Next" button.
- This will open another page to be filled which is filled as shown in Figure


Data Entry for Conservation Operation
Name of Structure (Alphabetic)
Hirakud Dam
Number of Immediately U/S Structures
1
IDs of Immediately U/S Structures (Space-Separated)
0
Gross Capacity at FRL 'MCM'
5896
Gross Capacity at MDDL 'MCM'
1074
Initial Capacity at Start of Simulation 'MCM'
5818.23
Method of Hydropower Supply
All Rel Pass through Plant
Reduction Factor for Irrigation in Scarcity (0 to 1)
0.75
Reduction Factor for Hydropower in Scarcity (0 to 1)
0.9
Factor Defining Critical Supply Conditions (0 to 1)
0.6
Factor for Converting Inflows to 'Cu.m'
1000000
Factor for Converting Power Demand to 'KW'
1000000
Factor for Converting Irrigation Demand to 'Cu.m'
1000000
Factor for Converting Domestic Demand to 'Cu.m'
1000000
Factor for Converting Min_Flow Demand to 'Cu.m'
1000000
Factor for Converting Transfer Demand to 'Cu.m'
1000000
Factor for Converting Elevation in E-A-C Table to 'm'
1
Factor for Converting Evaporation Depths to 'm'
1
Retrieve
Close
Save Data File
Clear
Specify E-A-C Table
Specify Demands and Rule Levels
Specify Evaporation Depths
Specify Inflow Data
Specify Monthly Priorities Irrigation (0) / Hydropower (1)
Specify Power Demand
Save Structure Information

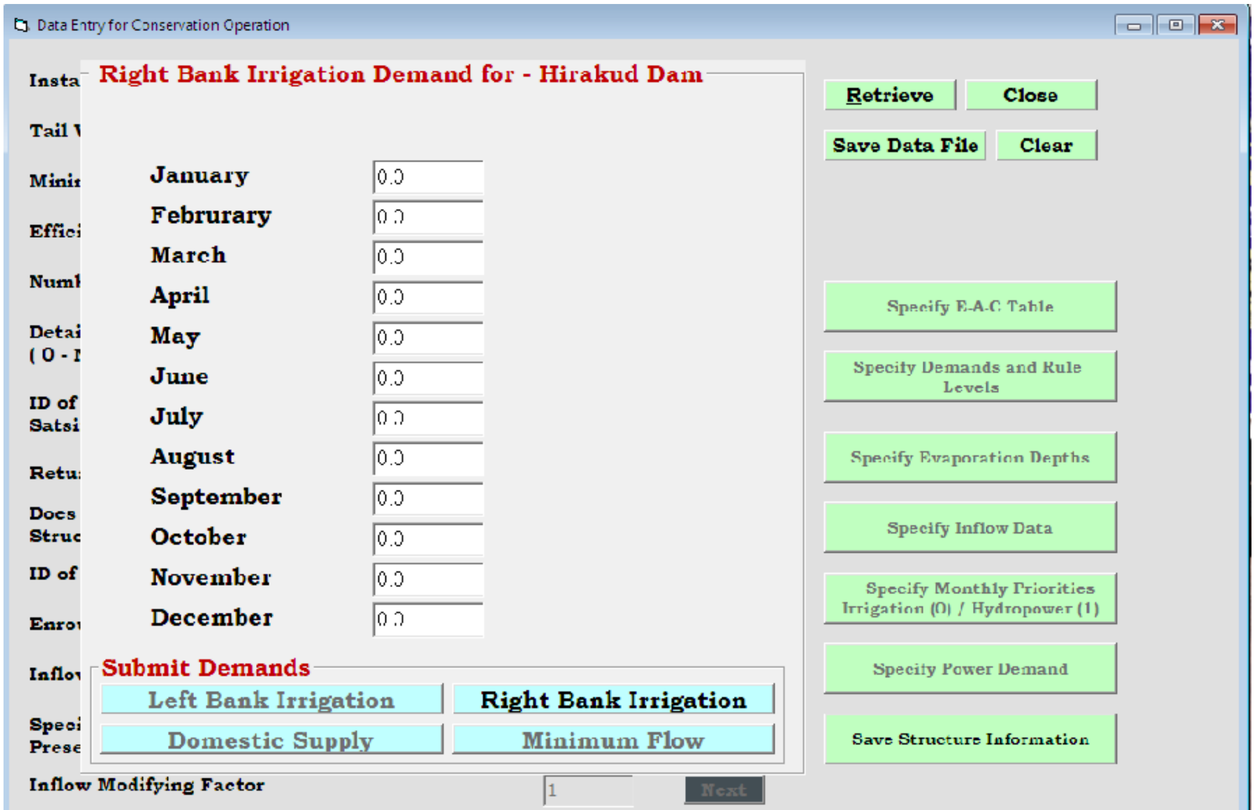
❖ Then click on the next button which will open another page to be filled as shown:



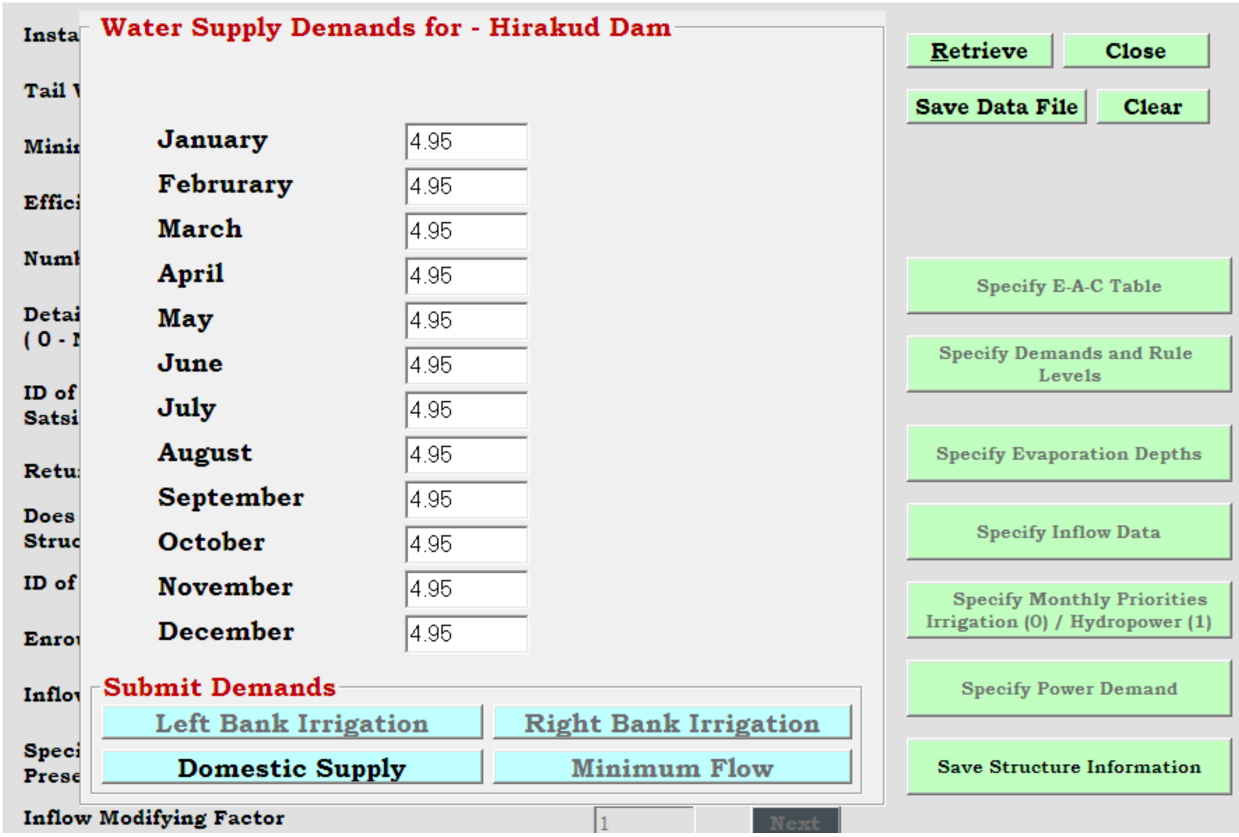
❖ After entering all these values "Next" button is clicked which activates the dormant icons.

❖ Then click on “Specify E-A-C Table” button which will generate a table with 11 rows and 3 columns. These data were provided earlier. So the table was filled with the provided data as shown:

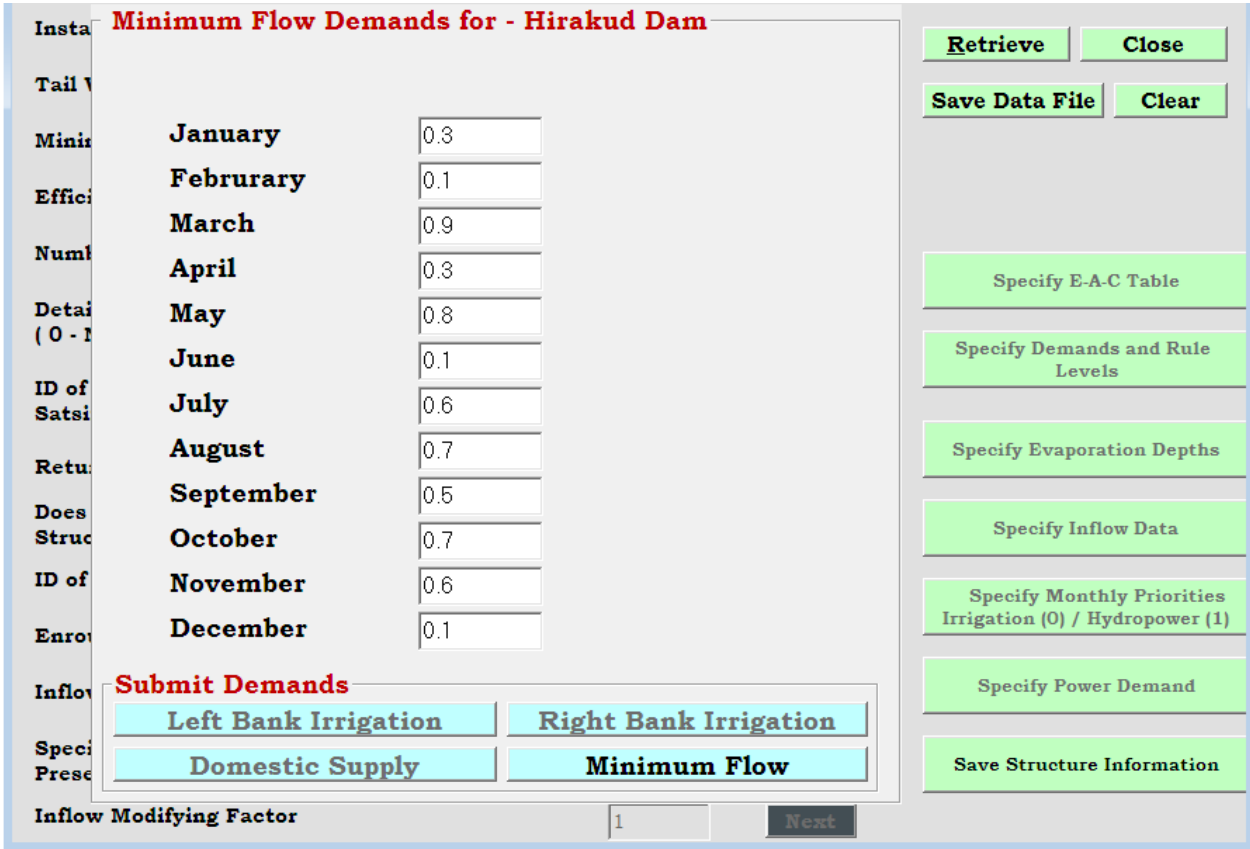
❖ After clicking on the “submit values” button click on “Specify Demands and Rule Levels” button which asked to fill the following data as shown in table:



These data are taken as 0 as there is no right bank supply for irrigation.



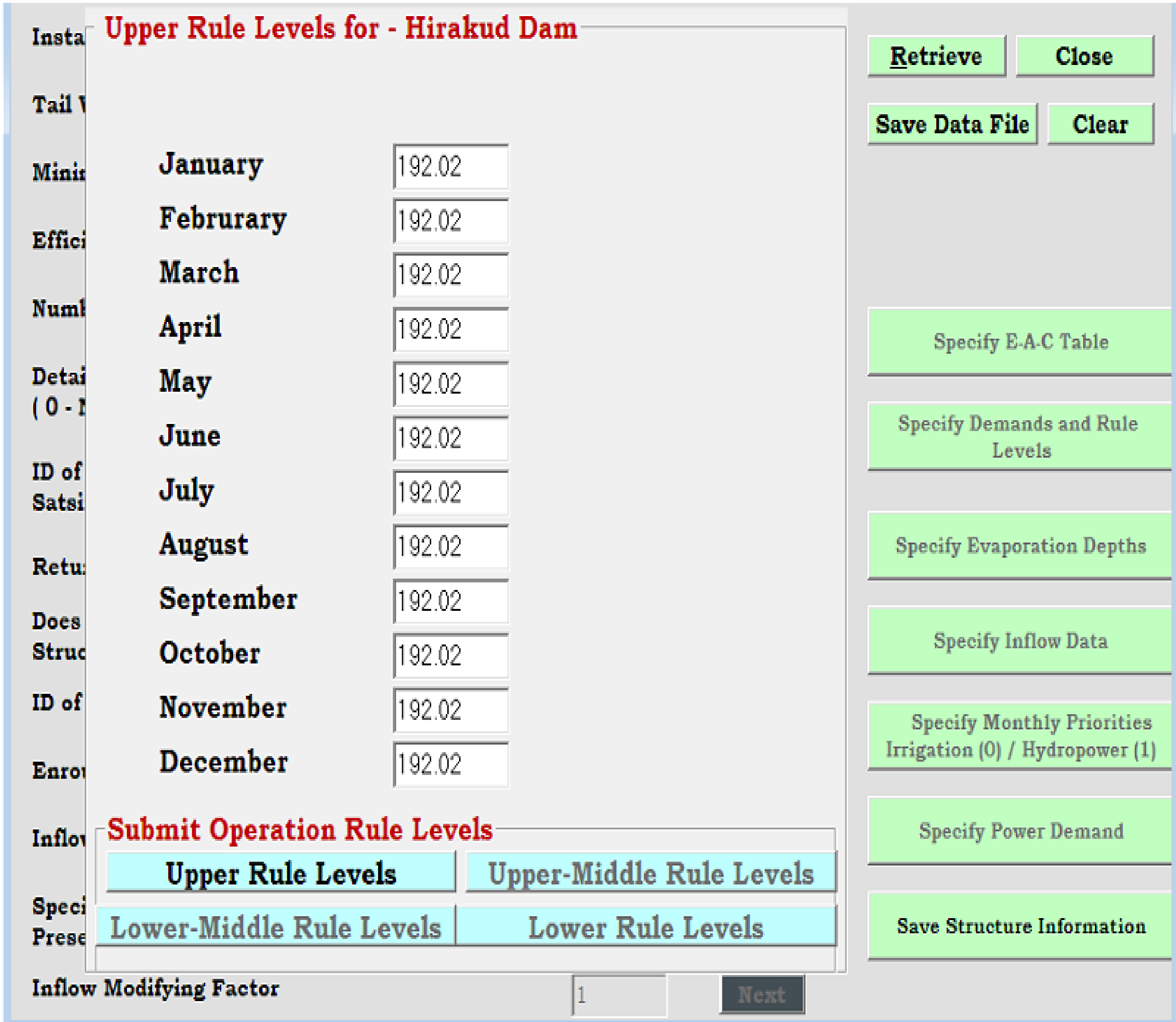
The normal water supply demand is taken as 4.95 MCM



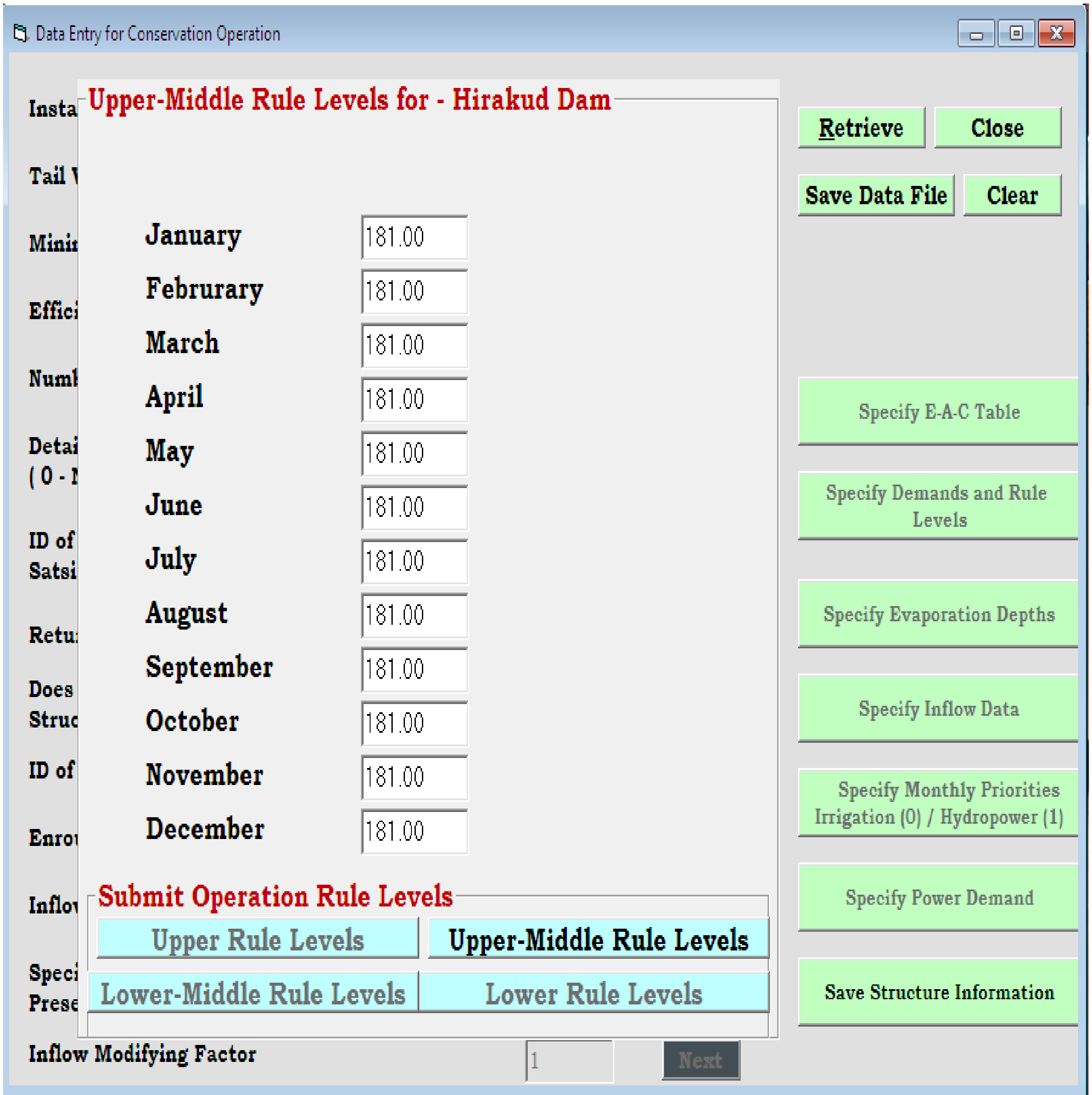
Minimum flow demands for various months of a year are specified.

Now all rule levels are specified as shown in figures:

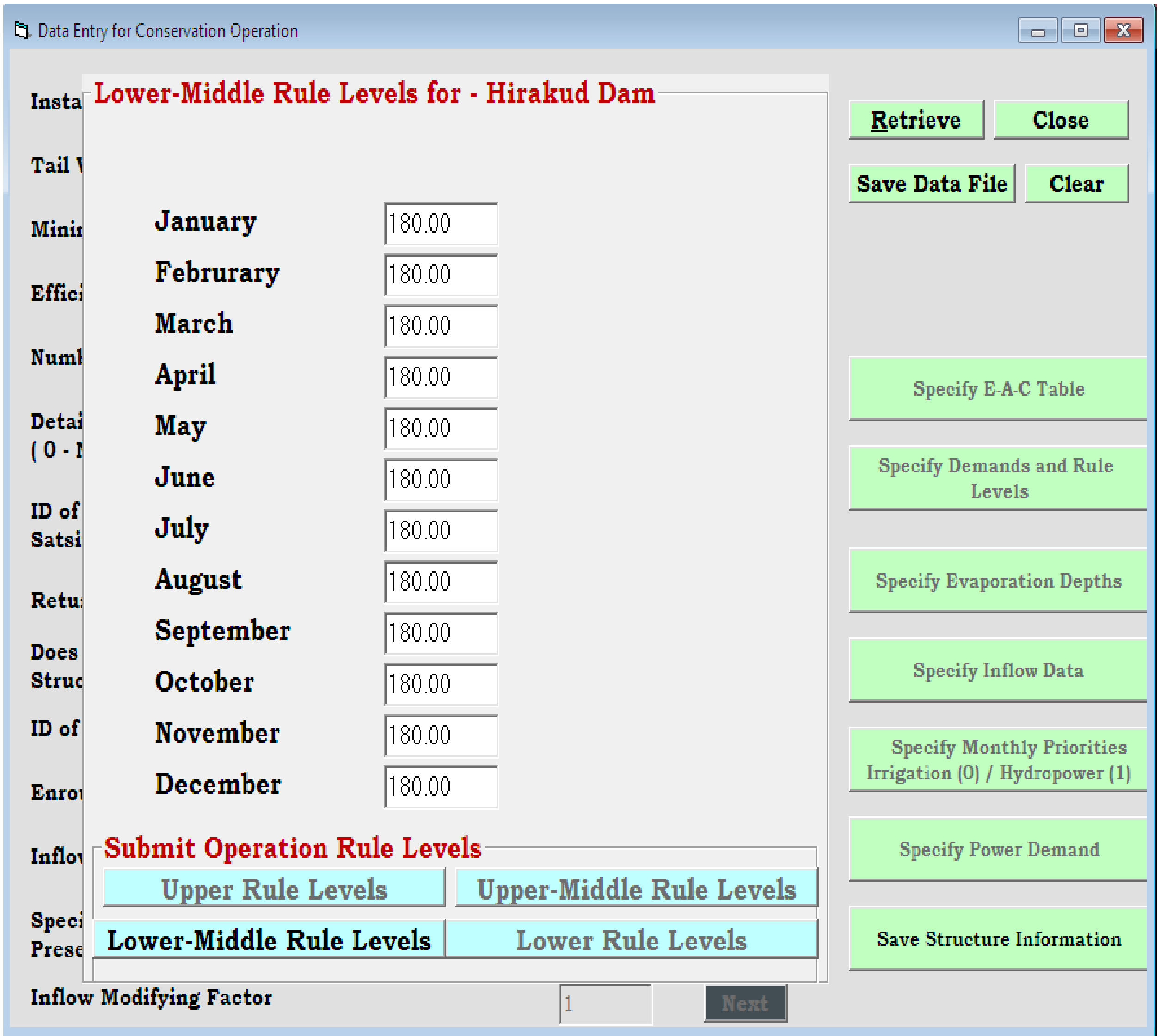
Upper rule level:



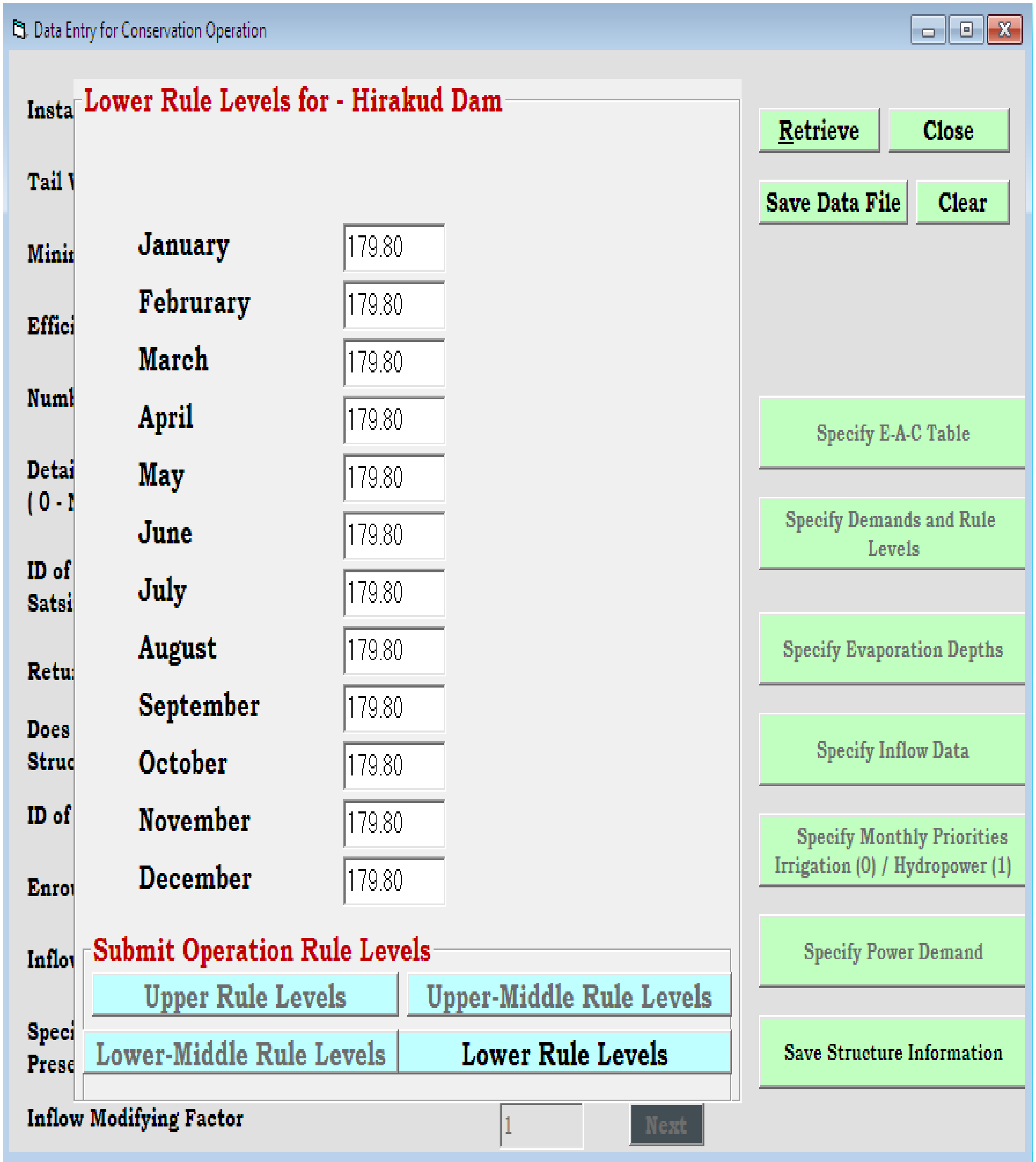
Upper middle rule level:



Lower Middle Rule Level:

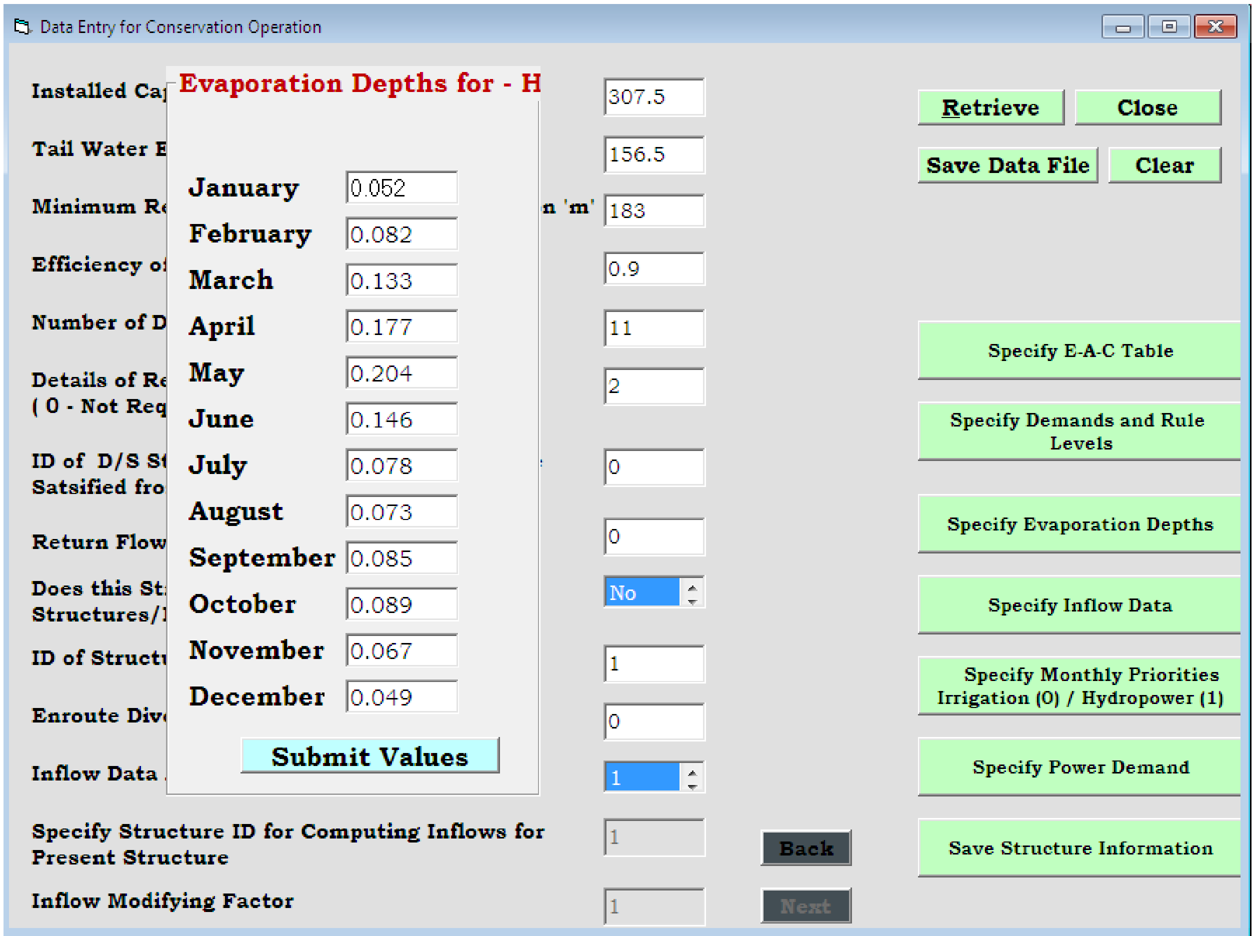


Lower rule level:



❖ Then evaporation depths for every month of a year followed by inflow data for 5 years is specified as shown

Evaporation depths:



5 years inflow data:

Press F1 for Paste

	Month	Inflow
	1	1043.52
	2	3984.14
	3	4246.87
	4	10896.56
	5	3177.44
	6	2038.48
	7	832.6
	8	525.6
	9	162.82
	10	46.87
	11	29.6
	12	156.05
	13	902.91
	14	2725.99
	15	9688.99
	16	10408.1
	17	3762.11
	18	1203.88
▶	19	651.28

Submit Values

Press F1 for Paste

Month	Inflow
20	352.16
21	270.13
22	77.17
23	60.44
24	112.25
25	552.6
26	3369.87
27	2948.02
28	2997.36
29	354.01
30	157.88
31	75.24
32	72.78
33	53.04
34	75.24
35	85.11
36	41.94
37	1622.03
38	21080.17

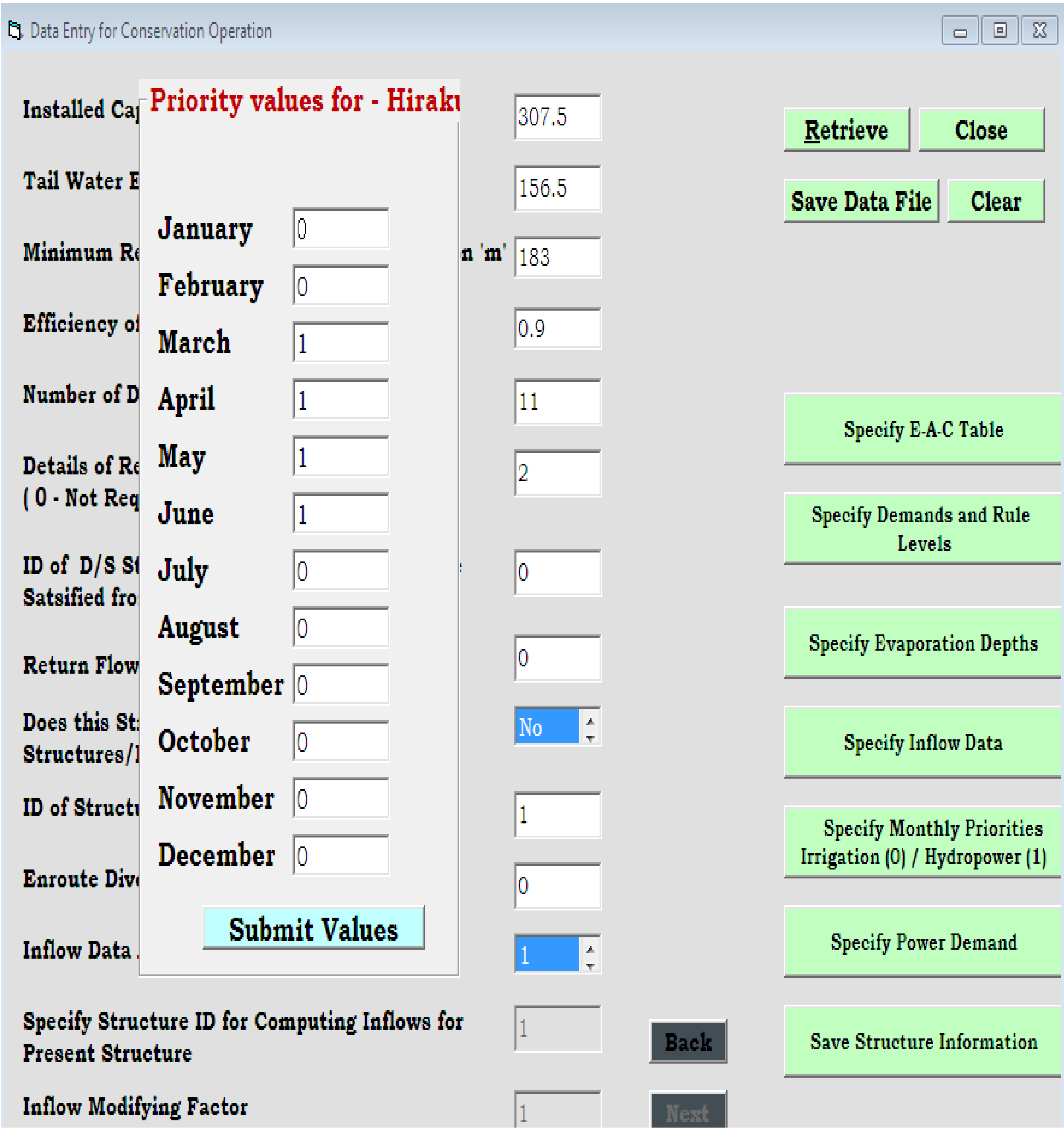
Submit Values

Press F1 for Paste

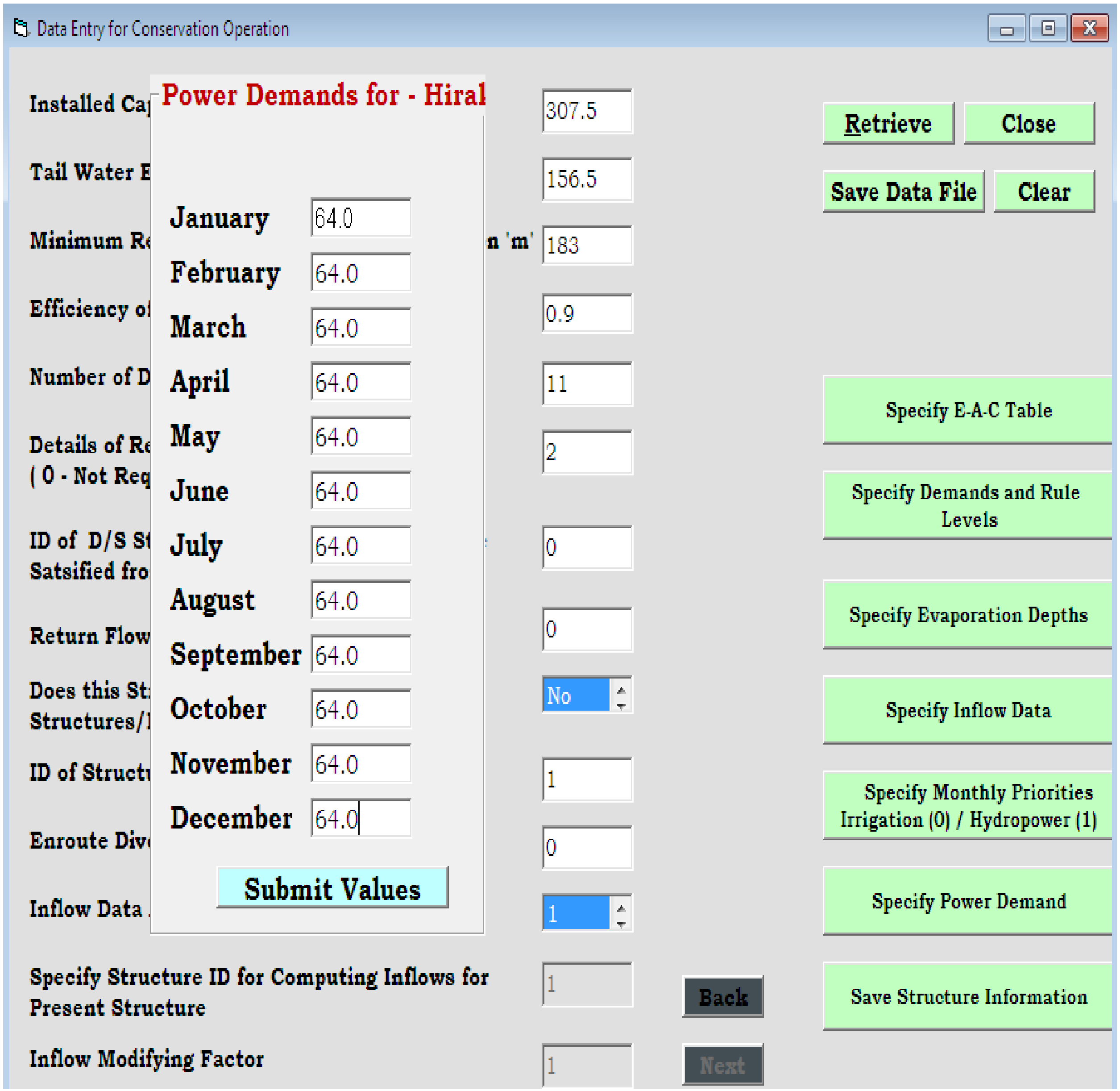
Month	Inflow
42	598.24
43	320.71
44	201.06
45	90.04
46	76.48
47	214.63
48	203.52
49	777.09
50	1175.51
51	4466.43
52	7419.38
53	732.69
54	240.53
55	106.08
56	91.28
57	98.69
58	88.81
59	107.31
60	71.54

Submit Values

❖ Priority values between Irrigation (denoted as 0) and Hydropower (denoted as 1) for different months in a year are specified:



❖ At last power demands are specified as shown:

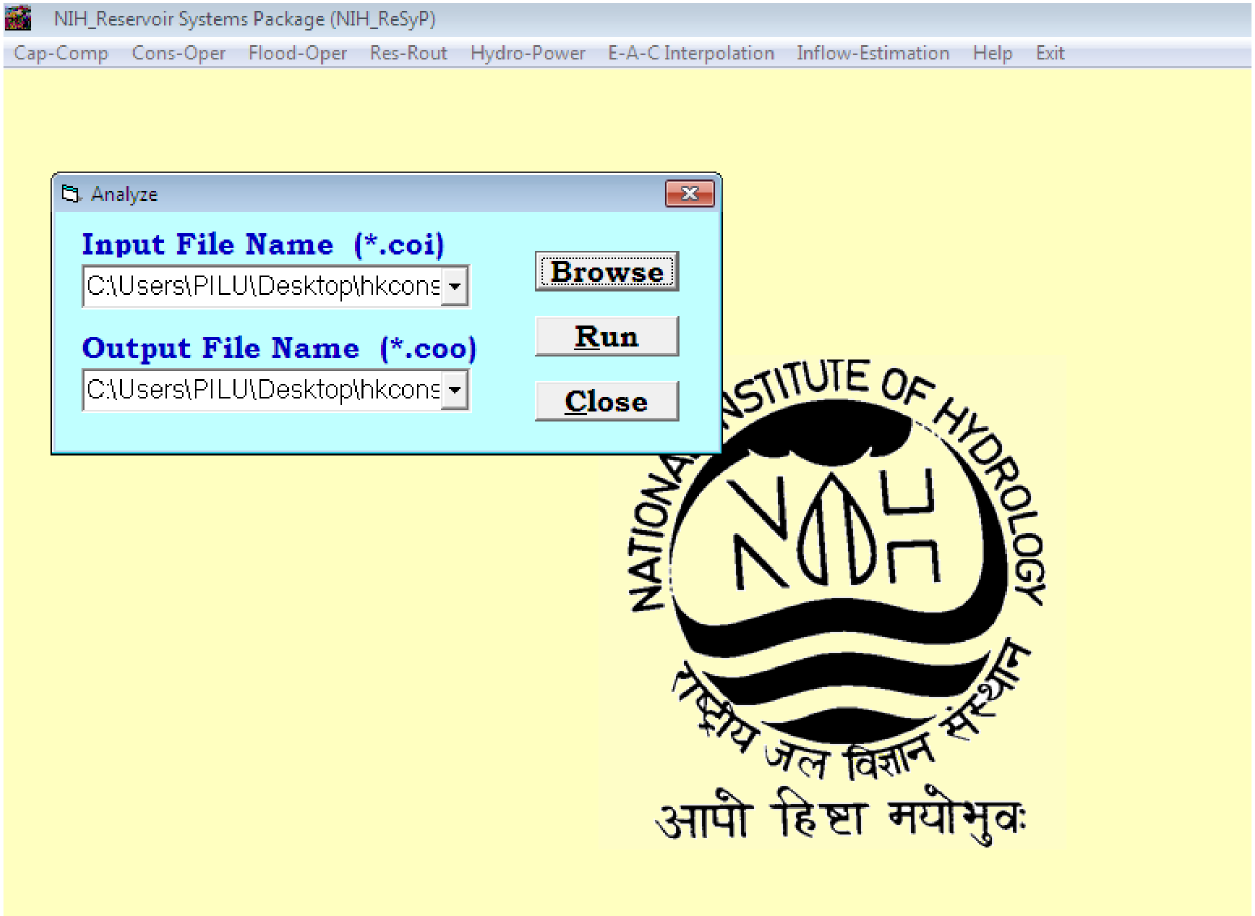


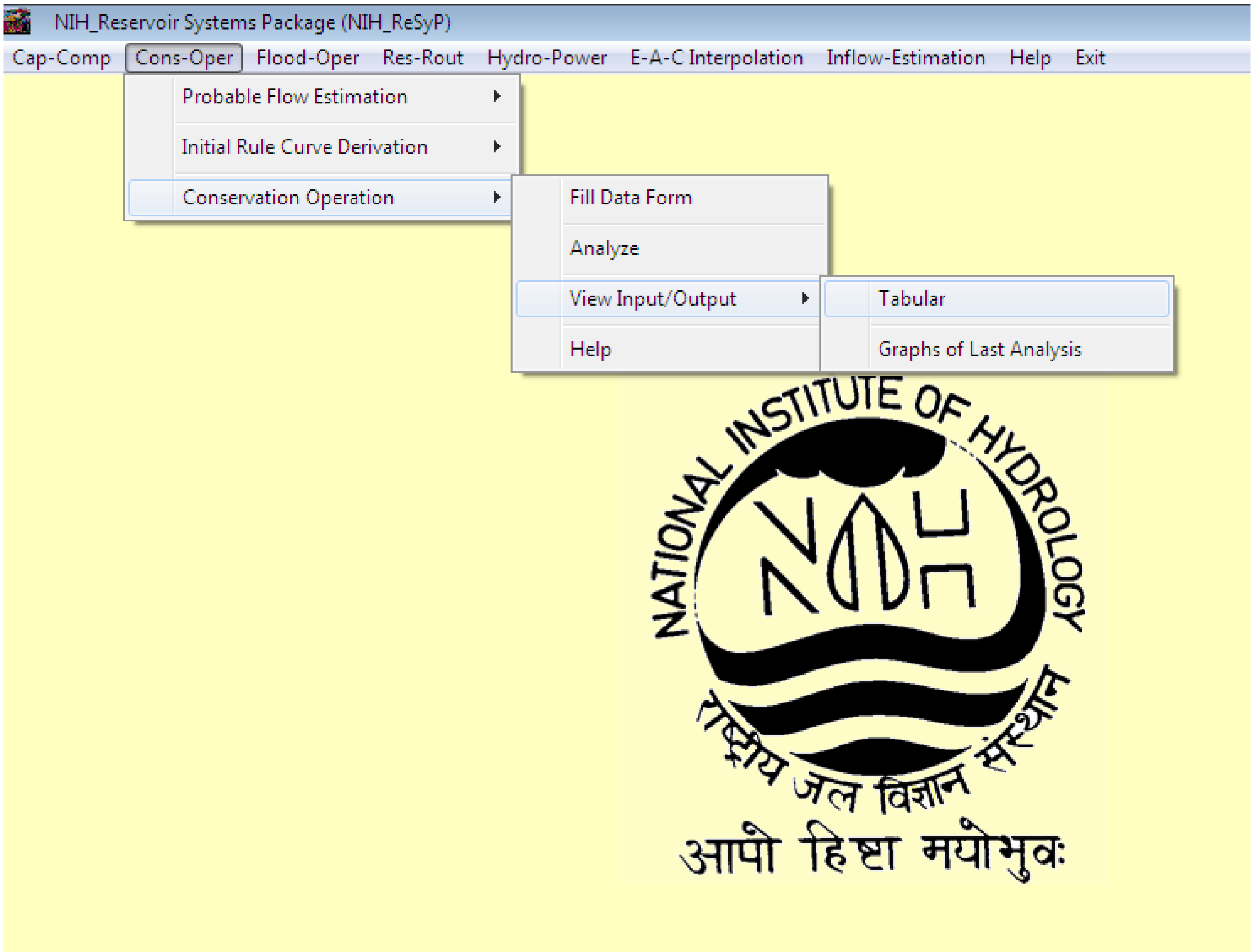
❖ After entering all data the structure information is saved with a file name which has a default extension of .COO and then the model is run .

- For running the program following steps were followed:

  - Revisit the main page of NIH-ReSyP .
  - Select the “Cons-Opr” module.
  - From the drop down list select the option “Conservation Operation”
  - Then select the option “Analyze” from the drop down.
  - A box for specifying input file path is activated. Click on browse button and select the required file which will show the path of the input file in the box.
  - After that specify the output file path by giving a name so that an object or file is created for the output data to be stored which can later be used.
  - Then click on the RUN button which will run the files in Dos prompt for some seconds and then click close.
  - Then again go to “Cons-Opr” select Conservation Operation and then select View Input/ Output which will give result in notepad format.

The operations are shown below:




NIH_Reservoir Systems Package (NIH_ReSyP)
Cap-Comp
Cons-Oper
Flood-Oper
Res-Rout
Hydro-Power
E-A-C Interpolation
Inflow-Estimation
Help
Exit
Probable Flow Estimation
Initial Rule Curve Derivation
Conservation Operation
Fill Data Form
Analyze
View Input/Output
Help
Tabular
Graphs of Last Analysis
NATIONAL INSTITUTE OF HYDROLOGY
राष्ट्रीय जल विज्ञान संस्थान
आपो हिष्टा मयोभुवः

Conclusion:

India is country where rainfall is seasonal i.e. few months of heavy rainfall is followed by dry period. So it becomes a tough task to have water availability throughout the year unless certain precautions are taken to conserve water by predicting future requirement. NIH-ReSyP is software where we can prepare a model of the reservoir and predict the flow of water for the days coming. This helps us to decide the minimum amount of water that should be maintained in reservoir so that a constant downstream flow is maintained, a constant flow to irrigating lands, a constant generation of hydropower using the data that were provided to it in the program. It also helps us to do a flood analysis or predict a design flood so that a level of water is maintained in the rainy season to avoid flooding of areas nearby. In case of a drought it helps us to estimate the reduction factors so that other demands of high priority are fulfilled.

References:

1. **K.C. Patra, 2001 - Water Resource Engineering.**
2. **Report of the High Level Technical Committee To Study Various Aspects of Water Usage for Hirakud Reservoir, August 2007 – Govt. of Odisha , Water Resource Dept.**
3. **NIH – Reservoir System Package Manual (Conservation Operation)**